Crystal Hybrid

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The article considers a variant of implementation of a hybrid RIAA corrector, in which an attempt was made to combine the advantages of solid-state and lamp devices.

Before plunging into technical subtleties, I would like to touch on a philosophical question: a why make correctors using archaic vacuum tubes at all. In spite of impressive objective characteristics of modern microcircuits, and indeed sound reproducing equipment, simple circuits with short paths on vacuum tubes do not lose to them at all in subjective testing, although they have much worse objective options. In principle, this applies not only to correctors, but also to other amplifying devices.

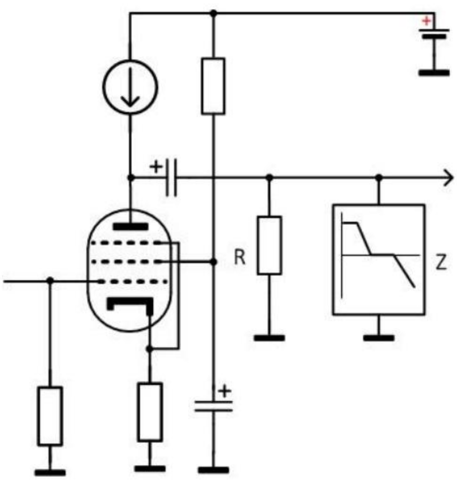
This leads to various seditious thoughts: either the traditional set of parameters characterizing the objective quality of the device is completely insufficient, or these are not those parameters at all, and in general, is this pursuit of thousandths of a percent of distortion, super symmetry and megahertz bands. To some extent, an attempt to answer this question was made in the work Cheever, and based on my experience, I agree with many of his conclusions. If we continue to develop this topic further, we can draw an interesting conclusion that at the forefront when designing audio devices should be set not so much to achieve a minimum level of all types of distortion, but to obtain a comfortable sound. Although the concept of "comfort sound" is very subjective and statistical in nature, but it is possible to approximately determine the area of its action and objective parameters that are strongly correlated with it.

Features of the transfer characteristics of electronic tubes and the very circuitry of tube devices allow you to get the desired result in fairly simple ways. On this basis various "improvers" of sound have been built, when elements that objectively worsen its parameters (electronic lamps or transformers). The situation is quite paradoxical - objective parameters are worse, subjective perception is better.

But the main thing here is not to overdo it. Again, statistically, the best subjective sound is short tube paths, and when the nature of the sound mainly determines the minimum amount components.

After a short digression, let's return directly to the corrector. So what did you want get: the minimum length of the audio path, the absence of a common OS, a large overload ability, low noise? Ideally, concentrate all the gain in the first and only cascade. For an MM head with an output of 3-5 mV, a gain of about 1000 is required (in the region of low frequencies). Such amplification, even with an excess, can be obtained in one stage using a pentode with sufficient slope and, for example, a current source in anode.

Theoretically, the cascade could look like shown in Figure 1. The current source in this case sets the lamp mode according to direct current. Assuming that the separating capacity is large enough, then the frequency-independent resistor R will set the maximum gain of the cascade in the entire working frequency band, and the desired frequency response forms reactive circuit Z. Despite the attractiveness of such a solution its practical implementation encounters a number of difficulties. Of course, the main problem is the high noise level typical for pentodes, the second problem is the low stability of the regime due to excessive DC gain.



Picture 1

And if the issue of regime stability is solved quite simply, and in some cases, by this can be simply neglected, then the issue with noise characteristics cannot be bypassed.

High gain can also be obtained from a cascode circuit, equivalent to the parameters of which are often compared with the cascade on the pentode. Of course, there is a little rhetorical question: is a cascode circuit two cascades or one complex cascade? But, since we the result is important, and the cascode circuit allows you to get the desired gain at a low noise level, then the circuit was converted to cascode (Figure 2).

It is known from the theory of cascode amplifiers [1] that the noise level of such a circuit is mainly determined by noise parameters of the lower amplifying element. To take full advantage of all the benefits circuit, a low-noise JFET transistor was used. it made it possible to obtain a noise level comparable to correctors on solid elements. Positive properties of the solution it doesn't end there. Using a JFET allowed to provide a sufficiently large operating current cascade, since the optimum in terms of noise characteristics transistor [2, 3] lies in the milliamp range, this beneficial effect on the frequency properties of the cascade and low frequency lamp noise. In addition, by changing the number of transistors connected in parallel, it is possible to minimize the level noise in accordance with the expected impedance of the signal source.

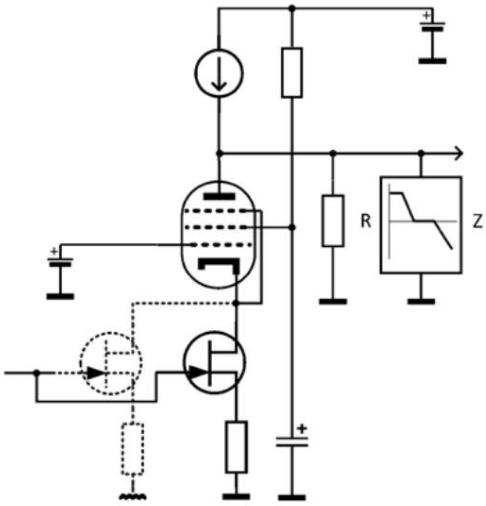


Figure 2

An isolation capacitor was excluded from the cascade, since it is possible compensate for the fixed DC current flowing into resistor R by trimming current source while maintaining the desired lamp mode. The very fact of eliminating the capacitor is already is positive, now the resistor R sets the gain at DC, and the capacitance of the frequency setting chains operate under a high polarizing voltage, which reduces the influence of parameters capacitor dielectric. The

cascade has a high output impedance, the calculated value is 4.1 megohm (which significantly exceeds the achievable values for the stage on the pentode). In fact, the cascade can be treated as a voltage controlled current source with a calculated conversion rate 8.4 mA/V. This allows you to adjust the gain within 10–15% (by changing the value of the resistor R without changing the parameters of the corrective circuit), without significantly affecting the frequency characteristics, this greatly simplifies the selection of active components.

Obviously, in order to exclude the influence of the subsequent cascade on the characteristics of the correctio must have a large input impedance and a minimum self-capacitance. Since we additional amplification is not required, then the natural solution would be to use a cathode or source follower. In principle, for example, when embedding a cascade in an integral amplifier input impedance of the subsequent stage can act as a resistor R (hundreds of kilos), but the requirements for the minimum input capacitance (units ÷ tens of picofarads) remain.

Corrector circuit

The complete circuit of the corrector is shown in Figure 3. The input uses low-noise selected JFET transistors 2SK170 (Toshiba), and the second amplifying element is a pentode 6BR7 (Brimar). Both the transistor and the lamp have been specially designed for use in low-noise applications. audio devices. Of particular interest is a lamp specially designed for use in input stages of microphone amplifiers, which, in addition to good sound properties and small with a high quiescent current (about 30 mA), which provides noise for lamps (extremely small) microphone effect. level The output follower (6Zh52P) operates low output impedance and painless operation on a significant interblock capacitance cable.

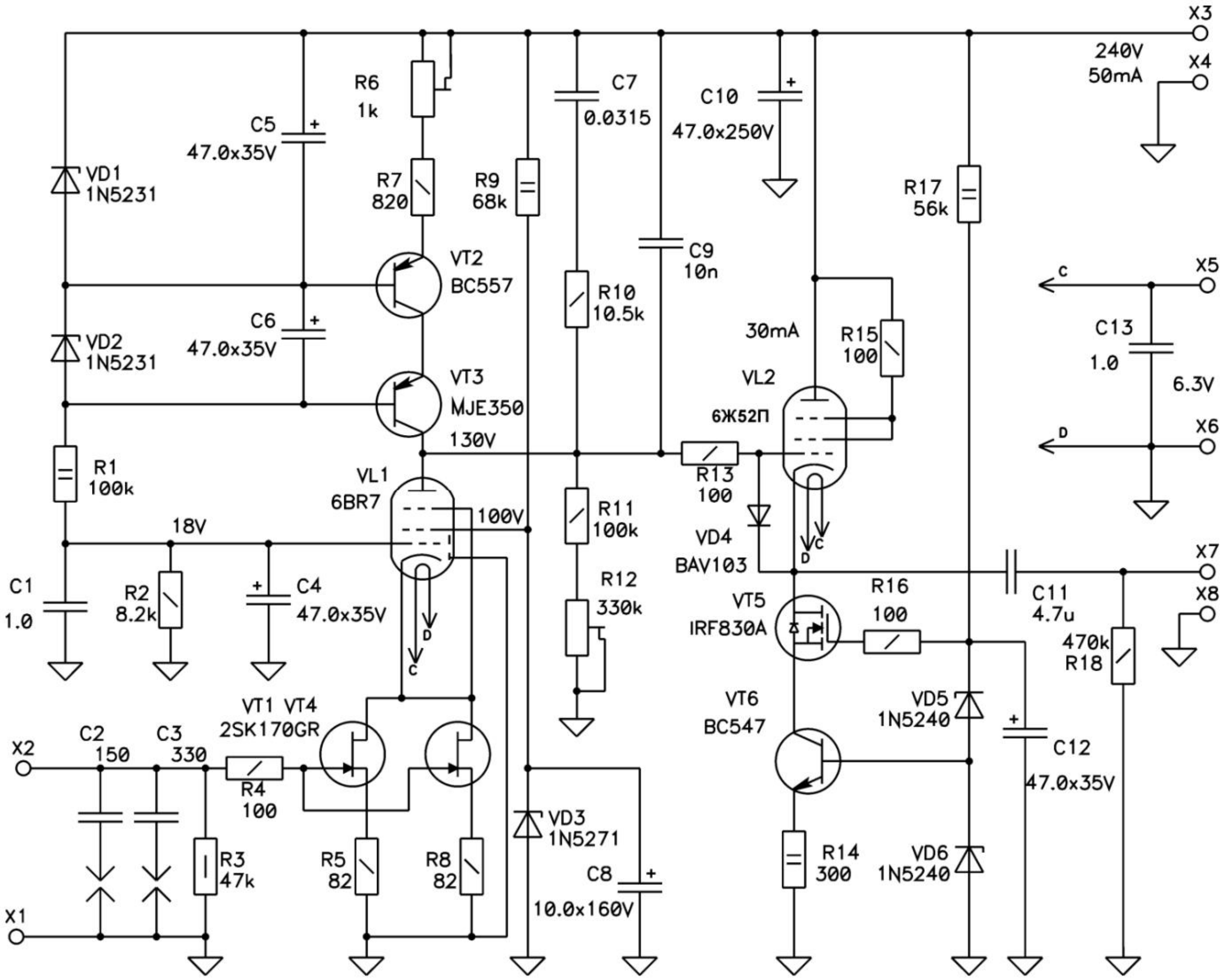


Figure 3

The corrector has a very low level of harmonics (only the second) and the nature of the introduced distortion, typical for tube devices. At the input of the corrector, an input capacitance selector is provided for matching with the head.

The corrector has the following parameters:

Gain (1kHz) Recommended input level
Input impedance Input capacitance THD (1kHz,
Uout=0.5Vrms) Noise level (not weighted) Overload
capacity Maximum output voltage Output impedance
Nominal load impedance Minimum load impedance
Correction specifications Specification accuracy

ÿ90
2÷5mV
47kÿ±0.1%
30÷500pF
<0.1% -85dB
+34dB 25Vrms
ÿ100 ÿ

47kÿ
10kÿ

RIAA±0.1dB

Structurally, the corrector is implemented on a printed circuit board, transistors VT3 and VT5 are equipped with coolers. For transistor VT3, an area of 1-2 cm2 is sufficient , and it is installed directly on the board, for VT5 need area 100-150cm2 , and it is placed on the chassis.

There are a number of fundamental requirements for a power source - the source must be stabilized, the anode voltage ripple level should not exceed 200-300 microvolts, the glow voltage ripple level should not exceed 5-10 millivolts. To stabilize the anode

voltage, you can use any of the stabilizers described on the site. For stabilization
filament voltage fit standard three-terminal stabilizers. Setting up the corrector is not very
difficult, but rather troublesome. For
settings, you need a low-frequency generator, a millivoltmeter and, of course, a multimeter. Resistors R6, R12
are pre-installed (multi-turn must be used) in
middle position. The supply voltage is applied, and the resistor R6 is installed on the anode of the first
130 volt bulbs. They check the presence and compliance with the voltage rating indicated in the diagram, a deviation of a few volts does not really matter, they control the current of the output stage - the allowable range is 27-35 mA. Let the circuit warm up for 15 minutes, adjust the voltage
on the anode VL1. Apply a signal with a frequency of 1 kHz, an amplitude of 5mV to the input and measure the signal level at the exit. Apply a signal with a frequency of 20Hz and a resistor R12 to the input, set the output
the voltage is 10 times greater (+20dB) than at 1 kHz. At the same time, resistor R6 maintains a voltage at the anode VL1 equal to 130 volts. They return to a frequency of 1 kHz, fix the value of the output voltage, again switch to a frequency of 20 Hz and adjust the level
output voltage to the desired value. The operation must be repeated several times. Finally, the output voltage level at a frequency of 20 kHz is checked. It should be 10 times smaller (-
20dB) than at 1kHz. If necessary, specify the value of the capacitance C9.

I want to note right away that the use of a 6BR7 lamp is desirable, but not necessary. Good
EF86 and 6Zh32P work. In principle, other small-signal pentodes corresponding to
the following criteria: nominal anode voltage - 130÷150 volts, low noise level, high slope, maximum output impedance. Of course, for other types of lamps
optimal modes will need to be redefined.

The corrector turned out to be quite audiophile both in terms of sound and in terms of operationÿ. The device requires 15÷20 minutes warm-up before listening. Although stability
modes for direct current turned out to be quite satisfactory (several devices successfully
has been working for quite a long time), but long-term stability, in my opinion, the scheme
insufficient.

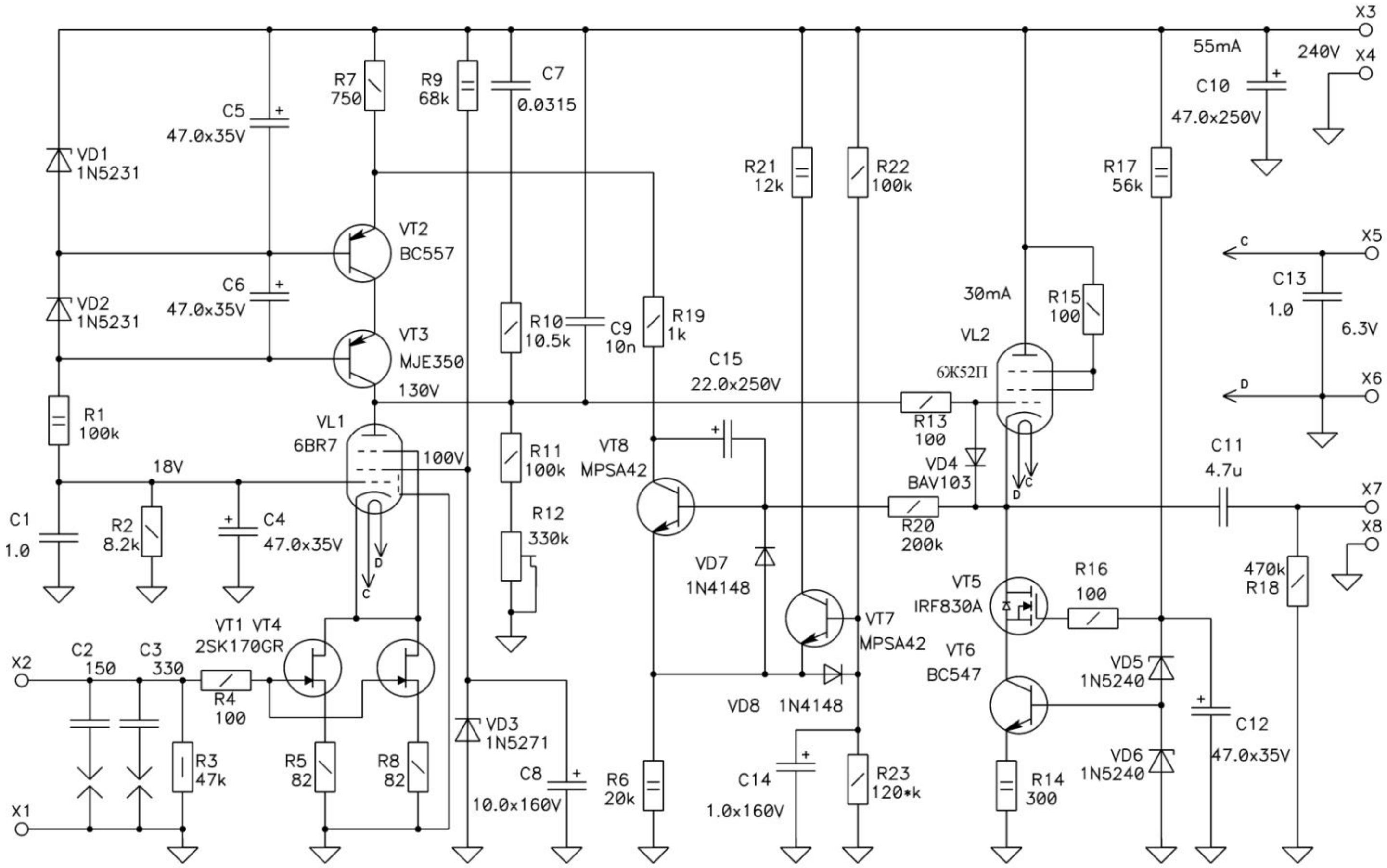


Figure 4

Figure 4 shows a modified version of the circuit, in which the issue of mode stability decisively resolved. Both cascades of the corrector are now covered by the stabilizing feedback at a constant current that maintains a given voltage on the anode VL1. The regime is maintained by regulating the current of the first stage. Cutoff frequency The OOS is chosen very low, and it does not affect the signal. The OOS loop is organized by the introduction two additional transistors - VT7, VT8. A reference source is assembled on the transistor VT7 voltage, and the transistor VT8 serves as a comparison element and the first stage of the error amplifier. AT the role of the second stage of the error amplifier and, at the same time, the actuating element, is cascode current source on transistors VT2, VT3. From the control system side, it can be be considered simply as a cascode amplifier loaded by the output impedance of the input cascade and the total resistance of resistors R11, R12 connected in parallel to it. In spite of ease of implementation, the stabilization system has high accuracy and stability, since the loop the gain reaches several thousand, and the intrinsic drifts of transistors VT7 and VT8 are negligible against the background of a high reference voltage.

Setting up this version of the circuit is easier, since the desired voltage at the VL1 anode is maintained automatically. After applying the supply voltage and warming up, it is necessary to install voltage of 130 volts at the anode VL1 by adjusting the value of the resistor R23. Permissible deviation from the nominal - 3 ÷ 4 volts in both directions. After that, adjust the transfer coefficient corrector at low and high frequencies (relative to 1 kHz) according to the method described above. AT during the tuning process, it is necessary to periodically monitor the voltage of the anode VL1. Range adjusting the current of the current source is deliberately limited, if for some reason the range is not enough, you need to expand it by adjusting the value of the resistor R19.
The power supply requirements are the same as for the previous circuit.

Conclusion

Although both schemes, with proper installation and serviceable parts, begin to work immediately, I do not presume to recommend them for repetition to medium-skilled lovers. In fact, herself the article is intended for readers with sufficient experience in designing and manufacturing solid state and lamp devices. The article omits the issues of choosing the types of components, installation, some aspects of the operation and calculation of typical units, on the assumption that this is all for the reader known.

I will omit the question of sound qualities, everyone should see for themselves. The only thing that I will say: this is definitely a tube corrector, with all the advantages of such devices.

Literature

1. Lozhnikov A.P., Sonin E.K., Cascode Amplifiers, M:, Energia, 1964. 2. Yezhkov Yu.S., Handbook of amplifier circuitry, M:, RadioSoft, 2002. 3. Buckingham M., Noises in electronic devices and systems, M:, Mir, 1986.